AXLE ASSEMBLY WITH TRANSVERSE MOUNTED ELECTRIC MOTORS

BACKGROUND OF THE INVENTION

[1] The present invention relates to an axle assembly which utilizes a plurality of electric motors, and more particularly to an axle configuration which locates the electric motors in a transverse arrangement to the axle.

[2] There is an increasing demand for the use of hybrid electric driven and hybrid electric assisted vehicles. Hybrid electric vehicles typically utilize electric motor driven axles which are often of a multi-axle configuration in military and specialty vehicles systems.

[3] The electric motors are typically sized to meet both torque and speed requirements which may not be the most effective for the operational requirements of such vehicles. Relatively large electric motors are often utilized to meet the torque requirements which may result in an oversized motor for most operational conditions. Moreover, the relatively large electric motors may be difficult to package in a multi-axle vehicle configuration.

[4] Accordingly, it is desirable to provide a lightweight and compact electric motor driven axle configuration which allows the usage of a multiple of relatively smaller electric motors for incorporation into a multi-axle military and specialty vehicle system.

SUMMARY OF THE INVENTION

[5] The axle assembly according to the present invention includes a first and a second electric motor which drives a gearbox assembly substantially therebetween. The electric motors drive the gearbox assembly which drives the vehicle wheels through a first and second axle shaft located along a first axis. The electric motors are located along axes which are substantially transverse to the first axis.

[6] The electric motors drive the gearbox assembly which includes a first stage gear reduction, a second stage gear reduction and a third stage gear reduction. The third stage gear reduction is preferably a two-speed reduction gear set that includes a differential gear set substantially contained within the two-speed reduction gear set. A relatively lightweight and compact axle assembly is thereby provided which will benefit from an electric motor of reduced size.

[7] Another axle assembly provides a third stage gear reduction which includes a single speed electric carrier. Yet another axle assembly utilizes only a single electric motor for yet another vehicle configuration without major modification to the axle assembly.

[8] The present invention therefore provides a lightweight and compact electric motor driven axle configuration which allows the usage of a multiple of relatively smaller electric motors for incorporation into a multi-axle military and specialty vehicle system.

BRIEF DESCRIPTION OF THE DRAWINGS

[9] The various features and advantages of this invention will become apparent to those skilled in the art from the following detailed description of the currently preferred embodiment. The drawings that accompany the detailed description can be briefly described as follows:

[10] Figure 1 is a general perspective view an exemplary multi-axle vehicle embodiment for use with the present invention;

[11] Figure 2 is a schematic sectional view of an axle assembly of the present invention;

[12] Figure 3 is a schematic sectional view of an axle assembly of the present invention; and

[13] Figure 4 is a schematic sectional view of an axle assembly of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[14] Figure 1 illustrates a schematic partial phantom view of a multi-axle vehicle 10 having a body 12 supported upon a frame 14. The frame 14 preferably includes a pair of main longitudinal members 16. It should be understood that although a particular vehicle arrangement is disclosed in the illustrated embodiment, other vehicles will benefit from the present invention.

[15] A multiple of axle assemblies 20 each includes an axle 22 driven by one or more electric motors 24. Each axle assembly 20 defines an axis of rotation D substantially transverse the longitudinal members 16 to drive one or more wheels 26. The electric motors 24 are driven by a prime mover 28 which is preferably a hybrid electric drive which powers each of the axle assemblies 20 by powering the electric motors 24. It should be understood,

however, that other prime movers such as diesel engines, gas turbines among others will also benefit from the present invention.

[16] Referring to Figure 2, a first and a second electric motors 24a, 24b drive a gearbox assembly 30 which drives the wheels 26 through a first axle shaft 32a and a second axle shaft 32b located along axis D and contained with an axle housing 34a, 34b. The electric motors 24a, 24b are located along axes DE1 and DE2 which are substantially transverse to axis D. The electric motors 24a, 24b drive the gearbox assembly 30 which includes a first stage gear reduction 36, a second stage gear reduction 38 and a third stage gear reduction 40.

[17] The first stage gear reduction 36 is driven by the electric motors 24a, 24b. The electric motors 24a, 24b drive a drive gear 42a, 42b respectively. Each drive gear 42a, 42b drives a single gear 44 which mounts a pinion gear 46 of the second stage gear reduction 38. Preferably, the single gear 44 and the pinion gear 46 are defined along a common axis A which is substantially parallel to the axes DE1 and DE2. The first stage gear reduction 36 preferably includes helical and/or herringbone gears.

[18] The pinion gear 46 of the second stage gear reduction 38 is mounted within a bearing cage 48 and bearing 50 which are mounted to a gearbox housing 52. It should be understood that the housing 52 may be constructed of multiple housing portions for assembly and maintenance purposes. The bearing cage 48 is axially adjustable relative the housing 52 through shims (illustrated schematically at 54). The pinion gear 46 is further supported at the gear end by a second pinion bearing 56. That is, the pinion gear 46 is supported by the single gear 44 at one segment, the second pinion bearing 56 at a second segment and at a third segment between the first and second segments by the bearing cage 48 and bearing 50. A rigid, yet adjustable mounting is thereby provided.

[19] The pinion gear 46 drives a hollow ring gear 58 through which the axle shaft 32a passes. That is the ring gear is coaxial with axis D. The hollow ring gear 58 is preferably mounted to an adjustment ring 60 mounted to the housing 52. The adjustment ring 60 provides for axial adjustment of the ring gear 58 to further assure proper tooth contact between the pinion gear 46 and the hollow ring gear 58.

[20] The hollow ring gear 58 drives the third stage gear reduction 40 through an input side gear 62a which is coaxial with axis D. That is, the hollow ring gear 58 is mounted to the input side gear 62a for rotation therewith.

[21] The third stage gear reduction 40 is preferably a two-speed reduction gear set 64 that includes a differential gear set 66 substantially contained within the two-speed reduction gear set 64 which drives a first differential axle side gear 68a mounted to the first axle shaft 32a and a second differential axle side gear 68b which drives the second axle shaft 32b.

[22] The differential gear set 66 is preferably nested within the two-speed reduction gear set 64. For further understanding of other aspects of the third stage gear reduction 40 and associated components thereof, attention is directed to United States Patent Application No. 10/_____ (Express Mail No. EV221419178US), entitled TWO-SPEED GEARBOX WITH INTEGRATED DIFFERENTIAL, which is assigned to the assignee of the instant invention and which is hereby incorporated herein in its entirety. A relatively lightweight and compact axle assembly is thereby provided which will benefit from an electric motor of reduced size.

[23] Referring to Figure 3, an axle assembly 20' provides a third stage gear reduction 40' which includes a single speed electric carrier that otherwise operates as describe with reference to the Figure 2 two-speed electric carrier. The hollow ring gear 58 drives a single speed electric carrier 59 of which is coaxial with axis D. That is, the hollow ring gear 58 is mounted to the third stage gear reduction 40' for rotation therewith. The single speed electric third stage gear reduction 40' is particularly preferred for a vehicle which, for example only, is of a lighter weight or which requires less off-road capability.

[24] Referring to Figure 4, another axle assembly 20" utilizes only a single electric motor 24a to illustrate that the axle assembly 20' of Figure 3 is module in nature. In other words, the first stage gear reduction 36 of the axle assembly 20" eliminates the electric motor 24b and the drive gear 42b to provide a relatively lighter duty axle assembly 20" for yet another vehicle configuration without major modification to the axle assembly 20'. The aperture for eliminated electric motor 24 is closed by a plug P or the like. Axle assembly 20" otherwise operates as describe with reference to the Figure 2 and 3 axle assemblies. It should be

understood that various combinations of the axle assemblies described herein may be provided to particularly tailor an axle assembly to a particular vehicle in a modular manner.

[25] It should be further understood that various bearing and seal locations are included within the gearbox. One of ordinary skill in the art, with the benefit of this disclosure, will consider the various bearing and seal locations to be an ordinary engineering problem such that intricate details thereof need not be fully discussed herein.

[26] The foregoing description is exemplary rather than defined by the limitations within. Many modifications and variations of the present invention are possible in light of the above teachings. The preferred embodiments of this invention have been disclosed, however, one of ordinary skill in the art would recognize that certain modifications would come within the scope of this invention. It is, therefore, to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described. For that reason the following claims should be studied to determine the true scope and content of this invention.